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ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/8 13/2
USE OF FABRICS AND OTHER MEASURES FOR RETARDING REFLECTIVE CRACK--ETC
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DOT-FA78WAI-837

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USE OF FABRICS AND OTHER MEASURES FOR RETARDING REFLECTIVE CRACKING OF ASPHALTIC CONCRETE OVERLAYS

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MARCH 1980
FINAL REPORT

Document is available to the public through the
National Technical Information Service,
Springfield, Va. 22151

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Prepared for

DEPARTMENT OF DEFENSE
DEPARTMENT OF THE ARMY
Office, Chief of Engineers
Washington D. C. 20314

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D. C. 20591

ADA 085851

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18 FAA/RD

Technical Report Documentation Page

1. Report No. FAA-RD-80-8	2. Government Accession No. AD-A085 857	3. Recipient's Catalog No. 12,530
4. Title and Subtitle <u>USE OF FABRICS AND OTHER MEASURES FOR RETARDING REFLECTIVE CRACKING OF ASPHALTIC CONCRETE OVERLAYS.</u>	5. Report Date Mar 1980	6. Performing Organization Code
7. Author(s) Ralph D. Jackson	8. Performing Organization Report No. MP-GL-80-2	9. Type of Report and Period Covered Final Report
9. Performing Organization Name and Address U. S. Army Engineer Waterways Experiment Station Geotechnical Laboratory P. O. Box 631, Vicksburg, MS 39180	10. Work Unit No. (TRAIS) Project No. 4K07812AQ61	11. Contract or Grant No. DOT-FA78WAI-837
12. Sponsoring Agency Name and Address Department of Defense Department of the Army Office, Chief of Engineers Washington, D. C. 20314	13. Type of Report and Period Covered Final Report	14. Sponsoring Agency Code
15. Supplementary Notes Prepared for: U. S. Department of Transportation Federal Aviation Administration Systems Research and Development Service Washington, D. C. 20591		
16. Abstract Prevention or control of reflection cracks in asphaltic concrete overlays has been a problem from the inception of this type of construction. The many different treatments that have been tried in an effort to solve this problem are: (1) reinforcement within and below the overlay, (2) bond breakers, (3) stress-relieving layers, (4) asphalt-mix additives, and (5) placement of fabrics between the existing pavement and the overlay. At the present time, no treatment has been tried that will completely prevent the formation of reflection cracks. Some treatments do delay the formation of cracks, while others do not appear to help at all. Indications are that fabrics do have some beneficial effects, such as a moisture barrier, even though the overlays develop reflection cracks. The fabrics that have been tried for the control of reflection cracks include: (1) Petromat, (2) Bidim, (3) Typar, (4) Cerex, (5) Mirafi, (6) Structofors, (7) Bituthene, (8) Protecto-Wrap, and (9) fiberglass. Asphalt-rubber interlayers, as formulated by the Arizona Refining Company and the Sahuaro Petroleum Company, show promise in retarding reflection cracks.		
17. Key Words Asphaltic concrete overlays, reinforcement, stress-relieving layers, bond breakers, asphalt-mix additives, asphalt-rubber interlayers, and fabrics	18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, Va. 22151	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 22
22. Price		

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

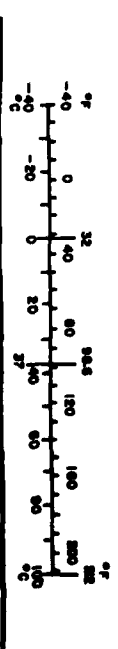
Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
m	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
m ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
cup	teaspoons	5	milliliters	ml
1/2 pt	tablespoons	15	milliliters	ml
qt	fluid ounces	30	milliliters	ml
pt	gallons	0.24	liters	l
qt	gallons	0.47	liters	l
gal	gallons	0.56	liters	l
1/2 gal	gallons	3.8	liters	l
1/4 gal	gallons	0.53	liters	l
yd ³	cubic feet	0.76	cubic meters	m ³
	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* 1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Inc. Publ. 286, Units of Weights and Measures, Price \$2.25, SO Catalog No. C13.110286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
km	kilometers	1.1	miles	mi
	kilometers	0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
ha	hectares (10,000 m ²)	0.4	square miles	mi ²
	hectares (10,000 m ²)	2.5	acres	ac
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	st
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	gallons	gal
l	liters	1.06	gallons	gal
m ³	cubic meters	0.26	gallons	gal
m ³	cubic meters	26	cubic feet	ft ³
	cubic meters	1.3	cubic yards	yd ³
TEMPERATURE (exact)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This study was conducted under authority of the Office, Chief of Engineers, U. S. Army, Operation and Maintenance (O&M,A) Project 4K07812AQ61, "Preventative Measures for Reflective Cracking of Asphaltic Concrete," and Department of Transportation, Federal Aviation Administration, Inter-Agency Agreement No. DOT-FA78WAI-837, "Fabrics in Airport Construction."

The engineers of the Geotechnical Laboratory (GL), U. S. Army Engineer Waterways Experiment Station (WES), who were actively engaged in this investigation were Messrs. A. H. Joseph, P. J. Vedros, H. H. Ulery, and R. D. Jackson, and Dr. G. M. Hammitt. The work was performed under the general supervision of Messrs. J. P. Sale and R. G. Ahlvin, Chief and Assistant Chief, respectively, of the GL, and R. L. Hutchinson, Chief of the Pavement Systems Division. This report was prepared by Mr. Jackson.

COL John L. Cannon, CE, and COL Nelson P. Conover, CE, were Commanders and Directors of the WES during the conduct of this study and publication of this report. Mr. Fred R. Brown was Technical Director.

TABLE OF CONTENTS

	<u>Page</u>
BACKGROUND	1
REINFORCING	2
BOND BREAKERS	3
STRESS-RELIEVING LAYERS	4
ASPHALT-MIX ADDITIVES	5
FABRICS	7
CONCLUSIONS AND RECOMMENDATIONS	13
REFERENCES	15

BACKGROUND

The cost of maintenance of pavements has increased greatly over the past several years, largely because of the increase in the price of petroleum. Improved design and construction methods must be found to reduce this cost if the military and civilian authorities are to continue to maintain pavements in the same condition as they have in the past. The era of low-cost energy has passed when one overlay after another could be constructed; thus, they cannot now be economically justified. Reflected cracks in bituminous overlays are one of the most significant factors in pavement deterioration. They permit the intrusion of surface moisture to the base, subbase, and subgrade, which in turn leads to less strength in the pavement structure. Many treatments have been tried over the past several years to prevent or retard the propagation of reflection cracks. A recent report published in 1979 discusses reflection cracking in airport pavements.¹

REINFORCING

One of the earliest treatments to prevent or control reflection cracks was the use of reinforcement under or within the overlay. The most widely used reinforcement was 10-gauge welded wire mesh, 3 by 6 in. (7.62 by 15.24 cm) or 6 by 6 in. (15.24 by 15.24 cm); however, 20-gauge hexagonal netting and 16-gauge expanded wire mesh were also used. Some installations placed the mesh directly on the existing pavement, while others provided surface preparation varying in thicknesses from a seal coat to as much as 2 in. (5.08 cm) of asphalt concrete. The total thickness of the overlay varied from as little as 3 in. (7.62 cm) to as much as 9 in. (22.86 cm). The performance of the wire-mesh reinforced overlays varied from fair to excellent with the overlay thickness having negligible effect.² Climate had a definite effect as the performance was much better in the warmer climates than in the cooler climates. This method has not been used for several years because it is expensive to install.

Asbestos fibers added to the overlay mix were used to a limited extent. Generally, the performance was good even though the thicknesses were much thinner than the wire reinforcement, 2 in. (5.08 cm) or less.² Two common problems with the fibers were introducing and distributing them into the mix at the pugmill and in the spreader as they had a tendency to form balls.

BOND BREAKERS

Fine-graded limestone sand, limestone dust, stone dust, and sand have been used along joints and cracks in portland cement concrete (PCC) to relieve the temperature stress between the overlay and the underlying pavement. The overlay thicknesses varied from 1.5 to 4.75 in. (3.81 to 12.06 cm). The performance in controlling cracks ranged from ineffective to excellent.² In 1963, at an installation on a taxiway at Tinker Air Force Base, Oklahoma, random cracks and joints were treated with limestone dust, 1/8 to 1/4 in. (0.32 to 0.64 cm) thick and 18 in. (45.72 cm) wide under a 4-in.- (10.16-cm-) thick asphaltic concrete (AC) overlay. After 16 years, this installation is still performing satisfactorily. The treated joints and cracks have not required sealing, whereas the untreated adjoining joints have required sealing. Only hairline cracks are now visible in the treated area.

Several other bond breakers have been tried--namely, aluminum foil, polyethylene, sisal paper, tar paper, and sheet metal. The performance of these materials was generally ineffective. None showed a definite advantage over the others.

STRESS-RELIEVING LAYERS

Aggregate base cushion courses, 4 to 8 in. (10.16 to 20.32 cm) thick, were placed on PCC with an overlay thickness of 3 in. (7.62 cm). The size of the aggregate was 1-1/4 in. (3.17 cm) and smaller. The performance of these installations ranged from fair to good.²

Large open-graded base course material is another treatment used as a stress-relieving layer. Table 1 shows three different gradations of base course material that has become known as "Arkansas base."³ Arkansas recommends a minimum thickness of 3-1/2 in. (8.89 cm) of the open-graded base, followed by a minimum of 1-1/2 in. (3.81 cm) of binder course with 1-1/4 in. (3.17 cm) of maximum aggregate, then a minimum of 1 in. (2.54 cm) of surface course. The length of time that crack formation is retarded can be attributed to the size of the aggregate. The larger the aggregate the longer the period before cracks reflect through the overlay.³ This treatment appears to be effective and economical in areas where large crushed aggregate is plentiful.

Table 1
Open-Graded Base Course Mixes for Crack Relief

Sieve	Percentage Passing		
	3-in. Max.	2-1/2-in. Max.	2-in. Max.
3-in.	100		
2-1/2-in.	95-100	100	
2-in.			100
1-1/2-in.	30-70	35-70	75-90
3/4-in.	0-15	5-15	50-70
3/8-in.	0-2		
No. 4			8-20
No. 8		0-5	
No. 100			0-5
Asphalt Cement AC-40	2.5-4.0	2.5-4.0	2.5-4.0

Note: 1 in. = 2.54 cm.

The State of Alabama tried a penetration surface treatment, 2 in. (3.08 cm) thick, that was placed under a 2-in. (3.08-cm) overlay, as a means of controlling reflection cracks. The performance ranged from fair to excellent.²

ASPHALT-MIX ADDITIVES

Lime, latex rubber, and neoprene rubber have been or are being used in an effort to control or retard the formation of reflection cracks. Only one known installation was made in which dry lime was added to the mix to control cracking.² The addition was 1 percent by weight of aggregate. A 4-in. (10.16-cm) overlay was placed over an AC pavement and was reported to have performed satisfactorily for 4 years.

A project being conducted by the U. S. Army Engineer Waterways Experiment Station (WES) for the U. S. Army Forces Command, Fort McPherson, Georgia, is the study of the effect of asphalt-rubber stress-absorbing interlayers and fabrics in the control of reflection cracks at Fort Devens, Massachusetts; Fort Stewart, Georgia; Fort Lewis, Washington; Fort Carson, Colorado; and Fort Polk, Louisiana. Two asphalt-rubber interlayers are being tested: a U. S. Rubber Reclaiming product formulated by the Arizona Refining Company, and a product of the Sahuaro Petroleum Company. The U. S. Rubber Reclaiming interlayer is composed of 80 percent liquid asphalt and 20 percent rubber by weight. The rubber is 40 percent powdered, reclaimed, and replasticized and 60 percent ground vulcanized rubber scrap. This mixture is sprayed on the existing pavement at a rate of 0.6 gal/sq yd (2.72 litres/sq m), followed by the application of 30-40 lb/sq yd (16.26-21.68 kg/sq m) of 3/8-in. (0.95-cm) maximum-size chips. The Sahuaro Petroleum interlayer is composed of 75 percent liquid asphalt and 25 percent granulated crumb rubber (100 percent vulcanized) by weight. The pavement has a light tack coat of liquid asphalt, 0.05 gal/sq yd (2.27 litres/sq m), sprayed on before the interlayer is applied. The mixture of rubber and asphalt is sprayed at the rate of 0.7 gal/sq yd (3.18 litres/sq m), followed by the application of 30-40 lb/sq yd (16.26-21.68 kg/sq m) of 3/8-in. (0.95-cm) maximum-size chips. At Fort Devens, a 2-in. (5.08-cm) AC overlay was placed over both brands of rubber-asphalt interlayers, with 1-1/2-in. (3.81-cm) overlays placed at Fort Stewart, Fort Lewis, and Fort Carson. At all four locations, test items were placed using both Mirafi 140 fabric, 4.0 oz/sq yd (135.62 g/sq m), and Bidim C-22,

4.5 oz/sq yd (152.57 g/sq m), under the same overlay thicknesses as mentioned above. In addition, a section of Petromat fabric, 4.2 oz/sq yd (142.40 g/sq m), was placed at Fort Carson. At Fort Polk, a Petromat fabric, 4.2 oz/sq yd (142.40 g/sq m), was placed on a 2-in. (5.08-cm) overlay that had been applied over a PCC pavement several years earlier. This fabric was covered with a 1-1/2-in. (3.81-cm) AC overlay. At Fort Lewis, another comparison is also being observed: the asphalt-rubber interlayer with chips versus a 1-in. (2.54-cm) AC overlay. All items were placed in 1977, except Fort Carson, which was placed in 1978.

FABRICS

In 1970, the U. S. Department of Transportation, Federal Highway Administration, initiated the National Experimental and Evaluation Program (NEEP) project No. 10, "Reducing Reflection Cracking in Bituminous Overlays." Five test features were originally suggested for trial in this project, which was to include the Petromat fabric. Approximately 13 states participated in the project with varying numbers of test items.

- a. Arizona applied a total of 18 test items with performance ranging from poor to excellent. The five best treatments in the order of preventing reflection cracks were: (1) heater scarification with Petroset, (2) asphalt-rubber interlayer, (3) fiberglass membrane, (4) heater scarification with Reclamite, and (5) 200/300 penetration asphalt. Arizona now specifies an asphalt-rubber interlayer under all overlays of 4 in. (10.16 cm) or less.⁴
- b. California placed Petromat in six areas with different temperature and precipitation ranges. The overlay thicknesses ranged from 0.08 to 0.35 ft (0.02 to 0.11 m). They concluded that the 0.08-ft (0.02-m) overlay life was extended 2 to 3 years by using Petromat in the areas where the temperature was mild. Another conclusion was that the fabric worked better over fatigue cracks less than 1/8 in. (0.32 cm) wide than over thermal cracks. Several other systems applied included: (1) open-graded AC base course under a dense-graded overlay, (2) rubberized slurry seal consisting of equal parts by volume of ground tire rubber, sand aggregate, and SS-1 asphalt emulsion, (3) conventional slurry seal, (4) rubberized chip seal, (5) Cerex, a spun-bonded nylon, and (6) heater remix. Performance of these six systems is not known.⁵
- c. Colorado placed nine systems under the NEEP program with varying degrees of success. The Petromat test items controlled cracking better than the other eight items and was recommended for high-traffic areas and severely cracked pavements. Other treatments tried in the order of crack prevention are: (1) emulsion slurry seal, (2) rubberized asphalt-cement, 1 percent neoprene by weight added to the AC mix, (3) Reclamite, (4) Petroset - rubber binder intended to bind asphalt particles together, (5) hand-poured crack sealing with CRS-2h, (6) heater-scarifier, (7) plant-mixed seal coat, and (8) squeegee seal - apply MC-70 and silty sand in cracks. Two other test items were placed using Cerex, a spun-bonded nylon, and Mirafi 140. The performance

of Cerex was fair. No performance data were available on the Mirafi items.⁶

- d. Florida tried seven procedures to control reflection cracks. All test items were placed over a 1-in. (2.54-cm) leveling course. The Petromat section performed best based on the percentage of cracking decrease between the crack survey before the overlay and the final survey. Other procedures ranked in descending order of their effectiveness in reducing crack appearance were: (1) 1-in. (2.54-cm) extra thickness of the AC overlay, (2) 1-in. (2.54-cm) open-graded mix before the overlay, (3) mineral seal placed on old pavement before the leveling course, (4) polyester fiber (Structofors), (5) Petroset, and (6) Reclamite. The base pavement for all items was AC.⁷
- e. Iowa placed three fabrics over PCC and over a widening joint between PCC and AC. Petromat, Cerex, and Structofors were about equally effective controlling reflection cracks over both the PCC pavement and the widening joint. Further testing was planned using Cerex and Petromat. Structofors is not planned for further testing due to the cost.⁸
- f. South Dakota used Petromat and Protecto-Wrap fabrics in an attempt to prevent the infiltration of surface water and snowmelt into the layers of the pavement system. Infiltration of water was causing ice lenses to form between the pavement layers with consequent heaving of the pavement surface. Plans were to place a 2-in. (3.08-cm) overlay over the fabric; however, due to the placement technique some areas had as little as a 1/2-in. (1.22-cm) overlay. Cracks appeared very soon in these thin areas and severe spalling occurred. The spalled areas were filled with a coarse sand slurry that did not spall. Observations revealed that the fabric had remained intact and that cracks in the overlay over the fabric averaged about 1/4 in. (0.64 cm) during the winter, while cracks in the original pavement averaged about 3/4 in. (1.92 cm). Moisture contents from under the fabric joints averaged about 10 points less⁹ than the moisture contents under the untreated joints.
- g. Texas tried several treatments to retard or prevent reflection cracks, including Typar, fiberglass, wire reinforcement, and Petromat. Typar was used as a water seal on the finished subgrade in an area of swelling soil. Whether this installation has been successful is not known. Fiberglass fabric was used at several locations; however, the performance is not known. The wire reinforcement gave generally acceptable performance. Petromat has been used at several locations throughout the state with varying degrees of success. On Interstate 40 west of Amarillo, three treatments were tried. One section consisted of (1) cement-stabilized base, (2) AC

leveling course, (3) Petromat, and (4) 3/4-in. (1.92-cm) AC overlay. Some cracks had migrated through to the surface; however, the condition was generally good. Another item had placed Petromat directly on the stabilized base course with a 3/4-in. (1.92-cm) AC surface course. This item was performing well even though some minor cracking was observed. The third item had a layer of large aggregate placed on the stabilized base course with a 3/4-in. (1.92-cm) AC surface course. No cracking was observed in this installation. These installations were placed in October 1976 and were approximately 1-1/2 years old at the time they were observed. In May 1978, Petromat was being installed over the PCC on U. S. Highway 87 near Canyon, Texas. It was being overlaid with 2 in. (5.08 cm) of hot-mix AC.¹⁰

- h. Virginia concluded that fabrics would retard the formation of reflection cracks over the PCC joints if the vertical displacement of the slabs was 0.002 in. (0.005 cm) or less. They observed that the asphalt-saturated fabrics over the PCC joints provided some protection against infiltration of moisture into the underlying layers.¹¹
- i. North Carolina reports that the four fabrics used in the tests were not superior to (1) mat course of No. 5 stone, (2) open-graded mix, (3) 2-1/2 in. (6.35 cm) of plant mix, or (4) sand seal.¹²
- j. North Dakota placed Petromat over the PCC pavement full width including shoulders. After 3 years, cracking in the Petromat section was slightly worse than in the control section.¹²
- k. Pennsylvania placed some small sections over badly alligator-cracked and rutted pavement. After 4 years, cracks were not reflecting. The overlay thickness was not available.¹²
- l. Wyoming installed Petromat over AC on Interstate 25 north of Casper. The overlay consisted of a 4-in. (10.16-cm) hot plant mix and a 3/4-in. (1.92-cm) wearing course. Cracks did not reflect through the Petromat overlay the first winter after placement; however, after two winters, the cracking in the Petromat section was the same as in the control section.¹²

Petromat was used at the Fayetteville Municipal Airport (Gronnis Field), Fayetteville, North Carolina. At numerous locations on the runways, the lane joints had separated, and other longitudinal cracking was occurring. In October 1977, fabric was placed over these cracks as a treatment to prevent or control the formation of reflection cracks. The cracks were routed and filled with hot plant mix before placing the fabric and the 2-1/2-in. (6.35-cm) AC overlay. No reflection cracking had occurred 8 months after construction.

At the New Hanover County Airport, Wilmington, North Carolina, Petromat was placed over both AC and PCC pavements before the construction of a 5-1/2-in. (13.97-cm) AC overlay in November 1977. The PCC pavement (taxiway C) was 10 in. (25.4 cm) thick with 12.5- by 25-ft (3.81- by 7.62-m) slabs. Petromat strips, 36 in. (91.44 cm) wide, were used over the joints for a portion of the taxiway, with the remaining portion being covered the full width of the taxiway. Cracks were reflecting through both treatments approximately 6 months after construction. Where Petromat was placed over AC pavements, no cracks had occurred since construction. The center 75 ft (22.86 m) of runway 5-23 had a control section, a 100-ft (30.48-m) section of single-surface treatment, and Petromat over the remainder. The outer 37.5-ft (11.43-m) edges also received a single-surface treatment before construction of the overlay. No cracking had occurred in any of the above treatments 6 months after construction.

In December 1979, Mirafi 140 was placed over an AC runway pavement at the Municipal Airport, Naples, Florida. About 80 percent of the runway was constructed in 1943 and 1944, and the remainder in 1946. The original construction consisted of a 2-in. (5.08-cm) bituminous surface course over a 6-in. (15.24-cm) bituminous-treated sand base. The 1946 construction consisted of a 2-in. (5.08-cm) bituminous surface course over an 8-in. (20.32-cm) limerock base. Maintenance since construction had consisted of a sand seal in 1965 and a slurry seal in 1971. From the crack survey report prepared before the overlay, the major portion of the cracks were old paving lane and block cracks associated with aging. At the time of observation, about 4 months after the 4-in. (10.16-cm) overlay was constructed, no reflection cracks were seen in the area where Mirafi 140 was used.

On Interstate 85 northeast of Atlanta, Georgia, the Georgia Department of Transportation placed Bituthene, Petromat, and Mirafi 140 over jointed PCC pavements with overlays of 2, 4, and 6 in. (5.08, 10.16, and 15.24 cm). After being in service for two winter seasons, 9 percent of the cracks and joints treated with Bituthene had reflected through the 2-in. (5.08-cm) overlay. No cracks had reflected through

the 4- and 6-in. (10.16- and 15.24-cm) overlays where the underlying cracks were treated with Bituthene. In the Mirafi 140-treated area, 86 percent of the cracks had reflected through the 2-in. (5.08-cm) overlay after two winter seasons. Cracking had not occurred in the 4- and 6-in. (10.16- and 15.24-cm) overlays. The Petromat-treated area had 68 percent of the joints and cracks reflected after two winter seasons. In addition, 7 percent of the cracks had reflected through the 4-in. (10.16-cm) overlay. No cracks had reflected through the 6-in. (15.24-cm) overlay. On State Route 20, Petromat, Mirafi 140, Bidim, and a Sahuaro asphalt-rubber interlayer were placed on an AC pavement that had severe cracking that was load-associated. The fabrics and asphalt-rubber were covered with a 1-1/2-in. (3.81-cm) AC overlay in 1976. Deflection studies indicated a need for at least a 4-in. (10.16-cm) overlay; however, only the lesser amount was placed for a quicker study of the effects of the interlayers. After approximately 1-1/2 years of service, no visible difference was apparent in any of the items. Overloading cracking was the only type observed.

At Fort Pickens, south of Pensacola, Florida, Petromat was used in the reconstruction and widening of the access road. The original roadway was composed of a series of surface treatments that had deteriorated to such an extent that reconstruction was necessary. The sand subgrade was stabilized with asphalt for a depth of approximately 6 in. (15.24 cm). This was followed with 6 in. (15.24 cm) of hot-mix sand-asphalt base course. A leveling course was applied, followed by Petromat overlaid with a 1-1/2-in. (3.81-cm) wearing surface. After approximately 1 year of service, no cracking was observed.

In March 1978, the Missouri Department of Highways installed four fabrics on a PCC pavement at randomly selected joints. The fabrics used were Bidim, Mirafi 140, Petromat, and Polyfelt TS200 under a 4-in. (10.16-cm) AC overlay. The installations were placed on U. S. Highway 36, east of Cameron in Caldwell County.

In May 1976, the Jackson County Highway Department, Independence, Missouri, placed Bidim C-28 over a severely cracked 6-in. (15.24-cm) PCC pavement that was constructed in the early 1930's. Both the transverse

and the longitudinal joints had wide separations. The Bidim C-28 was covered with a 3-in. (7.62-cm) AC overlay in May 1976. When observed in May 1978, very few of the cracks and joints had reflected through the overlay.

At McKellar Field, Jackson, Tennessee, four small test items were placed on a PCC taxiway. Sections of single-surface treatment, Typar, Mirafi 140, and Petromat were installed under a 2-in. (5.08-cm) AC overlay. Approximately 1 year after installation, the condition of the overlay was good, with no appreciable difference in any of the test items.

At Tampa International Airport, Tampa, Florida, two small test items of Petromat were placed under a 2-in. (5.08-cm) AC overlay over a PCC overlay of a PCC pavement. The PCC overlay was severely cracked. After approximately 6 months of service, only two reflection cracks were observed and one of these cracks was over an expansion joint.

In June 1978, Bituthene and Petromat were placed at Elmendorf Air Force Base, Anchorage, Alaska, over an AC pavement and covered with a 1-1/2-in. (3.81-cm) AC overlay.

In connection with another study being conducted at the WES, seven different fabrics were placed over PCC pavement joints under a 4-in. (10.16-cm) AC overlay in August 1978. The PCC pavement was 11 in. (27.94 cm) thick with slabs 20 by 20 ft (6.09 by 6.09 m). The average modulus of soil reaction k was 200 lb/sq in./in. (1378.94 kPa/cm). The second was constructed three slabs wide with one side having a keyed joint with the center slab and the other side having the slabs both keyed and tied. The fabrics used were 6- and 8-oz (170.09- and 226.79-g) Petromat, Bidim C-34, asphalt-coated Bidim C-34, Bituthene, Mirafi 140, and Typar K-17. All items except Bituthene and the coated Bidim were applied over a tack coat of SS1 anionic emulsion without any dilution. Fourteen joints were treated with fabrics. Of the 10 joints that required tack coats, five were tacked at the rate recommended by the manufacturers, and the other five were treated at rates either above or below the recommended amounts. All joints have some signs of reflective cracking; however, the side that has the PCC slabs both keyed and tied has the smaller cracks.

CONCLUSIONS AND RECOMMENDATIONS

In the review of the state of the art in the prevention of reflection cracks in AC overlays, it was concluded that:

- a. No known treatment will completely prevent the formation of reflection cracks.
- b. Some treatments do delay formation of cracks while others do not appear to help at all.
- c. Most fabrics perform better in temperate climates than in cold climates.
- d. Fabrics perform better over load-associated cracks in AC than over thermal cracks.
- e. Fabrics will not prevent reflection cracks over PCC if there is vertical movement between adjacent slabs.
- f. Petromat has been the most widely used of the fabrics.
- g. Controlled testing of fabric installations has been practically nonexistent.
- h. Indications are that fabrics have some beneficial effects, such as a moisture barrier, even though the overlays develop reflection cracks.
- i. Many fabric installations were placed where the underlying pavement was in such a condition that relatively thin overlays with fabrics were not sufficient to prevent or control the reflection cracking.
- j. Wire-mesh reinforcement has been successful in some installations; however, it is expensive to install.
- k. Bond breakers, such as stone, dust, limestone dust, limestone sand, and sand, have been used with varying degrees of success.
- l. Courses of large aggregate, maximum size 2-1/2 in. (6.35 cm) with only small percentages less than 3/8 in. (0.95 cm), have been effective in retarding reflection cracks; however, this procedure is expensive, especially in areas where the aggregate is in short supply.
- m. Rejuvenators added to heater-scarified AC materials have been moderately successful.
- n. Asphalt-rubber interlayers composed of ground tire rubber and asphalt show promise as a crack-retarding treatment.
- o. Bituthene has been successful on one test installation over PCC pavement. The particular highway department now specifies Bituthene under all overlays on PCC.

Based on this review of the state of the art for the prevention of reflection cracking in AC overlays, the following recommendations should be considered:

- a. Laboratory study and analysis should be made of the qualities needed in fabrics to satisfy the strength and elongation requirements that are necessary for their economical use in overlay construction.
- b. Laboratory study of asphalt-rubber interlayers should be made.
- c. Based on the results of the laboratory tests, controlled field test items should be constructed using the materials that possess the most desirable qualities.

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